Early Journal Content on JSTOR, Free to Anyone in the World

This article is one of nearly 500,000 scholarly works digitized and made freely available to everyone in the world by JSTOR.

Known as the Early Journal Content, this set of works include research articles, news, letters, and other writings published in more than 200 of the oldest leading academic journals. The works date from the mid-seventeenth to the early twentieth centuries.

We encourage people to read and share the Early Journal Content openly and to tell others that this resource exists. People may post this content online or redistribute in any way for non-commercial purposes.

Read more about Early Journal Content at http://about.jstor.org/participate-jstor/individuals/early-journal-content.

JSTOR is a digital library of academic journals, books, and primary source objects. JSTOR helps people discover, use, and build upon a wide range of content through a powerful research and teaching platform, and preserves this content for future generations. JSTOR is part of ITHAKA, a not-for-profit organization that also includes Ithaka S+R and Portico. For more information about JSTOR, please contact support@jstor.org.

THE

AMERICAN NATURALIST.

VOL. XVII. — *JANUARY*, 1883. — No. 1.

THE HISTORY OF ANTHRACITE COAL IN NATURE AND ART.

BY JAMES S. LIPPINCOTT.

THAT our anthracite has been debituminized is evident, but whence the heat that has thus changed its character is not so clear. It appears, says Dana, that the change has arisen from some cause connected with the uplifting of the rocks which contain the coal. In the anthracite fields the coal beds have been violently contorted, and the angles of dip are frequently vertical, and in some instances the beds have been entirely inverted. This is doubtless due to the corrugations of the coating crust of the earth which, from some cause, has operated more violently in the eastern than in the western section of the coal basins. The anthracite beds lie in closer proximity to the granite and gneissic bases of the Silurian rocks which form the lower substratum of the base of the coal rocks and thus were more fully exposed to the heating action of the earth's nucleus, and more completely debituminized. The pressure of the vast accumulation of superincumbent rocks must not be disregarded as a probable source of heat, and consequent chemical change. Under the influence of the elevated temperature and the great pressure which prevail at considerable depths, sedimentary rocks which have been long accumulating, would acquire a certain degree of fluidity and approach a temperature nearly equal to that of redness, and thus we may find a cause adequate to debituminize the bituminous coals into the hardest anthracites.

The more closely the coal strata are studied, the more forcible becomes the evidence that they originated in the manner of modern deltas. That the wood and fine sand exist without pebbles, and are stratified with the leaves and roots of terrestrial plants, free in most part from any intermixture of marine remains, imply the persistence in the same region of a vast body of fresh water. This water was also charged, as is a great river, with an inexhaustible supply of sediment, and such as would drain a continent having within it one or more ranges of mountains. A bed of coal, even when purest, consists of distinct layers, though not usually separable unless quite impure from the presence of clay. These layers may be distinctly seen as alternating shades of black, even in almost any of the hardest specimens of anthracite. The researches of chemists have proved that wood burned in the earth and exposed to moisture and partially or entirely excluded from the air, is converted into lignite or brown-coal. A long period of decomposition finally changes this lignite into bituminous, and subsequent decarbonization through the increased heat of pressure or proximity to the heated earth, converts this finally into anthracite. The gases that result are the fire damp so destructive to incautious miners.

The processes through which the beds of anthracite has passed may be outlined as follows:

The coal was formed at the level of the sea and afterwards lifted to a vast height, but the shrinking and crumpling of the crust has flexed these beds and the many sand and clay and limestone beds beneath them; the frost and rains have broken them down and the waves of the ancient sea have repeatedly rolled over them as they have many times subsided to be again raised and again acted upon by agencies above the water. But a small part of these coal beds, and of the great masses of rock which once towered to such vast heights, remain, and the greater the elevation the greater has been the destruction. Our beds of anthracite are now found only where the subsidence was very great —in troughs caught in foldings of the underlying rocks, being often nearly vertical and doubled and re-doubled upon each other. The old rocks were worn down, after the once horizontal deposits had been made to stand on edge at various angles to the horizon; the soft clays and limestones and sands were then washed into the ocean, or gathered into the deeper depressions in the contorted strata.

The Carboniferous period opened with a marked change over the continent. The red shales became covered with extensive beds of gravel or deposits of sand, which, hardening into a gritty rock, form the millstone grit and sandstone, which underly the coal measures. These fragments are the veins of some quartzose formations of former ages, which have again and again been cemented and re-broken, to repose at last a barrier against further destruction of the beds of coal. Forbidding as these barrier mountains may appear whence no valuable return could reward the cultivator, they may be regarded as proofs of the wisdom of the great architect who has provided that they should preserve, by their enormous eastward thickening, the secure basins hardened and toughened to resist further denudation, to become the strong storehouse of treasures more truly golden than all the glittering mines of Colorado and California.

"Coal," says Professor Newberry, "is entitled to be considered the mainspring of our [material] civilization. Wealth with its comforts, the luxuries and triumphs it brings, are its gifts, and its possession is therefore the highest material boon that can be craved by a community or nation." Coal is to the world of industry what the sun is to the natural world, the great source of light and heat, with their innumerable benefits. It is not only the principal generator of steam, but steam is also dependent upon iron, and the manufacture of iron is dependent upon coal, therefore these three most powerful among physical agents of modern advancement have their basis in the coal mine. "The exclusive possession of vast mines of anthracite within short distances from the seaboard, is one of inestimable value, and places Pennsylvania in an enviable position." "And it is difficult to say what vast populations its production alone will hereafter sustain, and to what height of power and importance it may ultimately elevate the State."

From Bethlehem we have followed the beautiful Lehigh, whose waters have been drawn largely into the canal, the massive walls and locks of which are a fitting measurement of the enterprise and indomitable energy of the father of the Lehigh coal business, and whose name is commemorative of the town which stands at the upper extremity of his noble work. The story of the efforts of Josiah White, of Philadelphia, and his indomitable pluck, deserves to be again and again rehearsed, conveying as it does a lesson of instruction to new men of new generations. It has been well told by his son-in-law, from whose work we extract one short notice of the labors of this extraordinary man.[1]

To the sagacity and perseverance of Josiah White, we are indebted for the planting of the seed that has grown to such gigantic proportions in the anthracite coal trade of Pennsylvania. Josiah White and Erskine Hazard, his partner in the manufacture of wire at the Falls of Schuylkill, early learned that they needed a liberal supply of fuel, such as would alone be found in mineral coal. Having obtained a small quantity from the Lehigh in 1812, the earliest brought to market, one of the first experiments in having it for manufacturing purposes was made at their works. "Incredible as it may seem at this day, great difficulty was found in causing it to ignite, mainly from want of patience and from the deficient draft of the furnace in which the effort was made to burn it. An entire night was spent in the vain attempt, when in despair the workmen shut the furnace door and retired and left the coal to its fate. Fortunately one of them had left his jacket in the mill, and on returning for it in half an hour later noticed that the door was red hot, and upon opening the furnace was surprised to find the mass at a glowing heat. The other workmen were summoned and four separated pieces of iron were heated by the same fire and rolled, before it required to be renewed." The secret of kindling anthracite had been discovered. In 1814 a few ark loads were brought down the Delaware, but the public was very unwilling to purchase, for said many "the black stones will not burn." Bryant records the distrust with which it was viewed in "A meditation on Rhode Island coal"

"Dark anthracite! that reddenest on my hearth,
Thou in those island mines dost slumber long,
But now thou art come forth to warm the earth
And put to shame the men that mean thee wrong;
Thou shalt be coals of fire to those that hate thee,
And warm the shins of all that underrate thee.

Yea, they did wrong thee foully, they who mocked
Thy honest face, and said thou would'st not burn,
Of leaving thee to chimney-pieces talked,
And grew profane, and swore, in bitter scorn
That men might to thy inner caves retire,
And there, unsinged, abide the day of fire."

---

[1] Memoir of Josiah White, showing his connection with the introduction and use of anthracite coal and iron, and the construction of some of the canals and railroads of Pennsylvania, etc. By Richard Richardson. Philadelphia: J. B. Lippincott & Co. 1873. 12mo, pp. 135.

White and Hazard procured a new supply from the head-waters of the Schuylkill, paying forty dollars a ton delivered in wagons at their works. Believing they could supply the needs at a cheaper rate by making the Schuylkill navigable, they applied to the Legislature for the privilege. But through the ignorant misrepresentations of the member from Schuylkill county, who assured the Legislature that " the black stone would not burn," they were unsuccessful. They were not the men to be thus thwarted, and we find them soon active in organizing an association for the improvement of the Schuylkill, which resulted in the present Schuylkill Navigation Company, incorporated in 1815.

Having failed to obtain coal from the Schuylkill region, either by law for the improvement of the river or afterwards from the Navigation Company, White and Hazard turned their attention to the Lehigh region. Coal had been discovered on the Lehigh as early as 1792 and a Lehigh coal company had been formed, but without a charter, which had sent a small quantity to Philadelphia, but owing to the difficulties of navigation it early abandoned the business. Some of the coal it is said, was tried under the boiler of the engine at Centre Square, in the first Philadelphia water works, but only served to put the fire out, and the remainder was broken up and spread on the walks as gravel.

Josiah White visited the Lehigh region in 1817, and returned home favorably impressed with the practicability of improving the river and mining coal. In company with his co-partners he obtained a lease of the coal company's lands for *an ear of corn a year*, if demanded; obtained a charter for the improvement of the Lehigh, and soon in person sat about leveling it from Stoddartsville to Easton upon the ice, with the only leveling instrument to be found in Philadelphia. They at first constructed a turnpike road descending 1000 feet in the eight miles from the mines to the river. The road was superseded by the gravity railroad in 1827. Josiah White, in the construction of the dams and walls labored with untiring assiduity, dressed oftentimes in a red flannel shirt, roundabout coat, cap and strong shoes with a hole cut in the toe, to let out the water. " In the summer I was," says he, " as much in the water as out of it for three seasons and slept for the first two without a bed, in the same manner as the workmen."

In 1820, they sent the first anthracite to market by their artificial navigation, the whole quantity being 365 tons, which was more than enough to supply the families who would use it, although they never asked more than eight dollars and forty cents a ton. To overcome the objection many found owing to the difficulties found in igniting the coal, Josiah White made many experiments with different kinds of grates, fixtures in his office and at his house in Philadelphia, and had a fire in operation for the inspection of the public, which showed the complete practicability of using anthracite for household warming, cooking, etc.

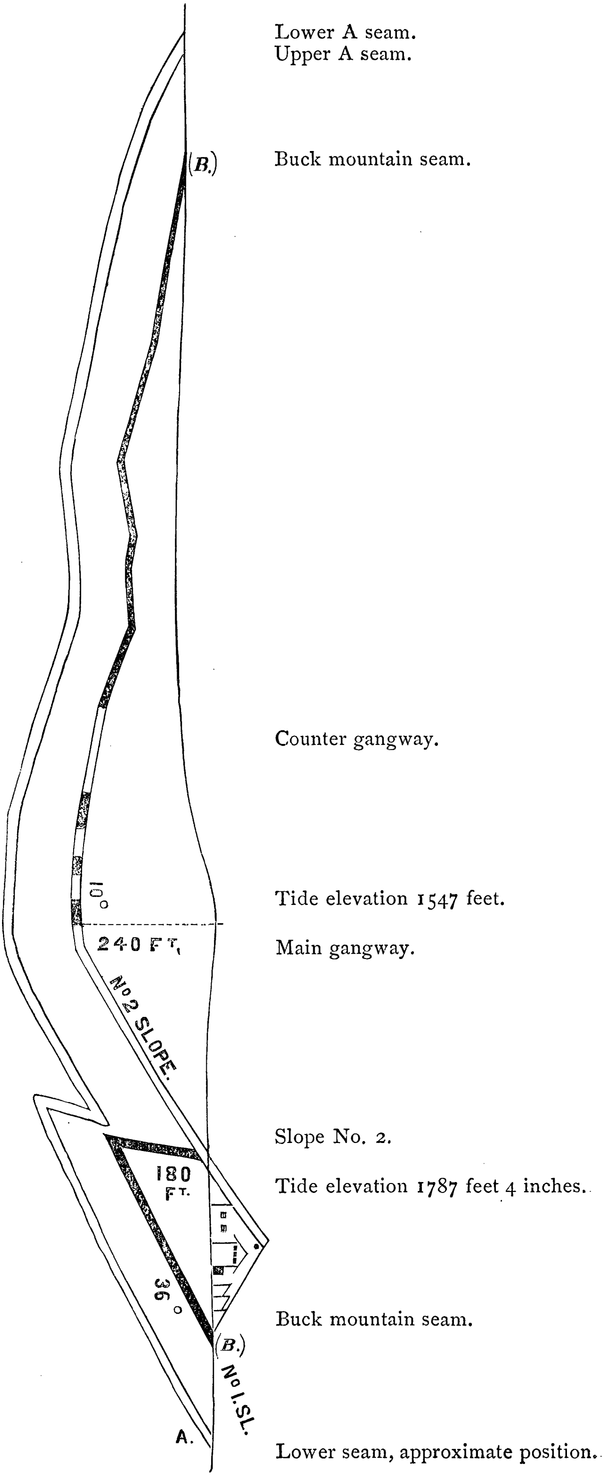
Though the company was mining or rather quarrying the finest mass of coal yet known to exist, the difficulties in the way of selling the stock or extending the works seemed to increase; but "there is no difficulty to him that wills," and by allowing new subscribers extraordinary advantages, the company obtained means to continue the improvements. In January, 1823, they were declared finished, and in this year, 5800 tons were sent down the Lehigh, and but about 1000 tons were left on hand unsold in the following spring. Josiah White had, about this time, contrived the present plan of weighing coal in wagons, with a scale, the dish resting on four knife-edged fulcrums and compound levers. His genius seemed equal to any emergency. In 1824, they sent down 9540 tons. The public had begun to believe in the permanency of the supply, and new forms of grates and stoves having been introduced and the price kept steadily at eight dollars and forty cents per ton, the demand increased. Several patriotic ladies exhibited sample-fires, and their glowing grates warmed the indifferent to a zeal for anthracite, making it popular, so that, in 1825, the company sent 28,393 tons to market. In 1827 the railroad from Mauch Chunk to the mines was made, mainly upon the old wagon route laid out by Josiah White and Erskine Hazard, in 1818. This was the first railroad in this country constructed for the transportation of coal, and, with one or two trifling exceptions, the first constructed for any purpose. This was a gravity road, having a descent of 100 feet per mile for upwards of nine miles. After the mules, which had hauled back the trains, had ridden down with the coal in a car made for the purpose of carrying them, they could not be forced to walk down again, being ever ready to enjoy the luxury of a ride.

Josiah White thus divides with another enterprising Friend, or Quaker, Edward Pease, of Darlington, England, the honor of having been a pioneer of railway enterprise. Edward Pease was the father of British railway enterprise; and was, like Josiah White, "a man who could see a hundred miles ahead." He was a man of excellent business abilities, energetic, and of most persistent stuff. Having been placed upon a committee to devise improved modes of conveyance from Stockton to Darlington, thenceforth his heart was in the project of a railway, till the act was passed in 1823, and the first railway was opened for traffic Sept. 27th, 1825, thirteen months prior to the opening of that between Liverpool and Manchester. The road built through the influence of Edward Pease was intended to aid in developing the vast mineral resources of his district, and but for his exertions and that of his sons, another generation might have passed away before the people of the region benefited could have enjoyed the marvelous prosperity with which they have been favored. The enterprise, courage and pertinacious genius of one man has tamed the uncouth savagery of nature, changed the dashing torrent into a placid canal, turned the wilderness into a busy abode of happy industries, opened to day the treasures hidden for ages, and poured them out to bless his fellows and advance more rapidly the ever progressing course of human development. When from the summit of Mount Pisgah the admiring tourist gazes upon the wonderful scene spread before him, and regards the railroads with their immense trains of coal, the canal bearing its burdened boats, the activity everywhere visible in this hive of industry, let him turn to the memory of Josiah White, and apply to him the words as aptly written of another, *Si ejus monumentum requiris circumspice.*

Arrived at White Haven, we leave the Lehigh Valley road and take the Nescopeck branch. This carries us for nine miles up an incline which, at some places, rises upwards of 147 feet to the mile, while it follows seemingly every curve that could be readily devised in its winding track. Mountains are around us and above us, and red rocks and gray rocks and white sandstone—pebble rocks succeed in order piled in endless variety of attitudes—until we at length are deposited at the simple station at Upper Lehigh, and we have reached a height of 1850 feet above the sea. We are in the midst of a coal basin, small, it is true, but of immense value. The Green Mountain basin is but about two and a quarter miles in extent, and is worked at five slopes which supply three immense coal-breakers and turn out annually 300,000 tons of superior coal. This basin exhibits the manner in which the beds have been laid down and corrugated very satisfactorily. Its twelve feet vein is the lowest workable bed, and is known as the Buck Mountain seam, one of the most valuable for furnace use. The blocks of white quartzose conglomerate lie in wild confusion around, a white sandy soil prevails, and a wilderness of whortleberry bushes, overtopped by sorrowing pines, are among the unattractive features of the landscape. We are compelled to look far away for beauty, and we find it in the long green masses of the Buck mountain, towering in the distance in the south, and in the hazy Pokono, sixty miles away to the east, in the dim distance. A pleasant walk of half a mile will bring us to a mass of giant rocks, from which we may look down into the wide and deep ravine bearing the repelling name of "Hell Kitchen," from the blasts of hot air that at times arise from its depths. From this pleasant outlook we may extend our gaze over and beyond the Butler valley, or Nescopeck, as it is also termed, to find our view bounded on the north by the mountains of that name which arrests our otherwise extended range of vision; even to the Wyoming mountain, the southern border of that valley long known to fame, and sung by Campbell as

> "Once the loveliest land of all
> That see the Atlantic wave the morn restore."

We will leave the scenery around us near and far, and devote ourselves for the remainder of this too extended paper to the unromantic but deeply interesting facts of coal mining. In wandering about the wilderness we came upon great sink-holes, which marked the places where the underpinning had broken and permitted the superincumbent mass of rock to descend. In these places there appeared a mixture of broken coal and sand, indicating the outcrop of the great coal seam. At a point near our hotel this has been opened, and a slope and steam engines and coal breaker, and all the busy industries of coal mining are vigorously in action. At the No. 1 slope the coal seam descends at an angle of about 30° until it has reached the perpendicular depth of 180 feet. The bed then rises nearly vertical, and approaching the surface, sinks again at nearly the same angle to the depth of 240 feet, and thence lies, as it extends southward, beneath and across the valley at an angle of 10°, more or less, being



SECTION THROUGH SLOPE 2 UPPER LEHIGH COLLIERY. 1880.

Scale 400 feet to the inch.

somewhat flexed from the level until it runs out on the southern edge of the basin. At the summit of the second dip another slope has been opened, and between these two slopes stands the giant coal-breaker, supplied with coal by the action of immense engines which draw, by means of wire rope, the loaded cars to its lofty height. The coal is drawn, in the second slope, up an incline of 424 feet by means of a wire rope 4300 feet in length, and nearly two inches in diameter. About 600 cars are daily hoisted by this rope, and the cars are drawn 174 feet up the incline within the breaker alone. This anticlinal, flexure, or saddle, brings into near proximity to the breaker a vertical mass of coal twelve feet in thickness and nearly 200 feet in height, and extending eastward and westward up and down the valley, to thin out as the conglomerate rises, basin-like, to its outcropping edge.

During 1880 there were three breakers in the basin, employing 389 men inside and 215 outside the mines. To open the mine and break up the coal from its beds 1514 kegs of powder, weighing twenty-five pounds each, were used, and the product of 330,444 tons of coal of 2240 lbs. each were sent to market. This valley and its plant for mining is the property of one family, and has proved, under their enterprise and energy, a princely domain.

——:o:——

THE DEVELOPMENT OF THE MALE PROTHALLIUM OF THE FIELD HORSETAIL.

BY PROFESSOR DOUGLASS H. CAMPBELL.

AMONG the vascular cryptogams, perhaps none can be more satisfactorily studied than *Equisetum arvense*, both as regards the structure of the mature plant and that of the *prothallium*, the plant being a common one, and readily obtained for study. The growth of the fertile plant is very rapid, so that the cells are large and distinct, and being comparatively free from the silicious deposit so noticeable in most of the other species, it is much less difficult to examine. Finally, and what is of chief interest here, the spores germinate very readily if sown immediately after maturing, and offer a most interesting example, in their development, of the growth and division of cells. Within a few weeks of sowing, the antheridia are produced abundantly, containing antherozoids of extraordinary size, much larger than those of the mosses and ferns.